International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN(P): 2249-6890; ISSN(E): 2249-8001
Vol. 9, Issue 2, Apr 2019, 477-484

THE ENGINE TESTING WORK-FLOW ANALYSIS THROUGH VALUE STREAM MAPPING AND SIMULATION

SREEJYOTHI. R, THENARASU. M & GOKULACHANDRAN. J

Department of Mechanical Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore, Tamil Nadu, India

ABSTRACT

In this paper, a detailed study has been made at an automotive industry to analyse the engine testing line to improve the productivity. The challenges faced by the industry in engine testing work flow is identified as lack of coordination due to difficulties in accommodating the changes in schedule and test cell priorities, productive time wastage in waiting for parts and delayed movement of palletized engines. Other issues which added up in the problem scenario includes availability of skilled labour and work requirement which are not perfectly synchronized and the lack of proper space allocation due to the random placement of engines in the build area. Among all the engines which are being tested, a single model of engine which is of most priority for the customer is chosen for analysis. The data regarding the arrival of engines per day, time and manpower required for each task, and daily installations of engines in test cells are collected. A regression model with the distribution that fits the data is given as the input for modelling and simulation. Further the points of improvement identified through value stream mapping (VSM) are considered for enhancing the entire work flow. Through simulation the optimum number of workers to be engaged in each operation and the possibilities of performing parallel activities and thereby reducing the total time for engine installations are obtained and also, a better layout for the build area where these operations are conducted is figured out. Future State Value Stream Map is plotted showing the possibilities for reducing non-value added activities and changes that need to be adopted for improvement in each operation and thus, an optimized workflow for engine testing is obtained.

KEYWORDS: Value Stream Mapping (VSM), Discrete Event Simulation (DES) & ARENA

Received: Jan 25, 2019; **Accepted:** Feb 15, 2019; **Published:** Mar 09, 2019; **Paper Id.:** IJMPERDAPR201946

Original Article

1. INTRODUCTION

To meet the ever-increasing customer demand in terms of quality and quantity of products companies are in a constant pursuit to find new methods and to improve the existing ones to ensure higher productivity. Lean technologies are the initiative taken by companies to identify and eliminate waste in each step of the workflow, which will in turn lead to improved productivity and an enhanced efficiency. Among the various tools in lean technology Value Stream Mapping (VSM) is the technique which is adopted in this research project to analyse the actual material and information flow present in the company.

VSM can be applied to eliminate waste, and improve operational procedures and productivity and there is lot of opportunities for improvement in the process industries like automobile industry if lean tools are utilized [1,2]. Value-added and non-value added activities can be analysed in an automotive part manufacturing plant and VSM can be used as a visual tool to help see the hidden waste and sources of waste [3]. And simulation can be used to answer questions that could not be addressed only using the static view provided by VSM [4, 5].

By applying simulation and Value Stream Mapping the manager can see the impacts before implementation and transform the organization into a minimal cost [6,7]. Simulation model in Arena software can be developed to contrast the ‘‘before’’ and ‘‘after’’ scenarios in detail, in order to illustrate to managers, potential benefits such as reduced production lead-time and lower work-in-process inventory [8]. VSM template is also present in the Arena, which allows the user to create maps in the Arena which can be pasted into presentations, which are also working simulation models [9, 10]. Value stream mapping (VSM) and discrete event simulation can also be applied as decision-making tools to direct the management invest in the best option among the available scenarios generated by the simulation system [11,12].

As a part of research and development process in the company the engines are continuously being tested to identify and rectify the problems present in them. Number of test cells are present, which are engaged with various tests depending on the demand from the customer. Since customers are paying for the test cell utilization, the time duration in which the test cells are down for installation purpose is of very high importance. The engine installation downtime can be reduced by improving the productivity of the included processes and by reducing the time wastages. For this purpose, a detailed study of the processes included in the installation, the time required and manpower utilized for each operation need to be conducted. The work flow of engine installation can be understood through the work flow diagram given in figure1.

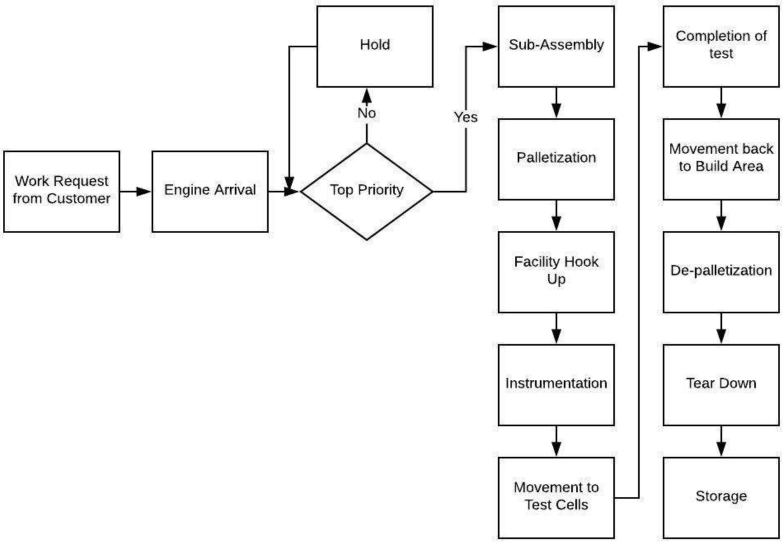

Figure 1: Current Work Flow Diagram of Engine Installation and Testing

From the workflow diagram, it is observed that all activities are done one after the other, therefore the delay occurred in one activity affects the upcoming activities and thereby increasing the total trough put time.

1.1. Problem Scenario and Objectives

This work is conducted in the build area where engine readiness is being done prior to installation in the test cells. A number of problems are identified by observing the workflow pattern and man power allocations. Several small issues are clustered together into four main issues which will give an overview about the problem scenario present in the company. These issues are lack of coordination due to difficulties in accommodating the changes in project schedule and test cell priorities, productive time wastage is observed due to waiting for parts and delayed movement of palletized engines, availability of skilled labour and work requirement is not perfectly synchronized and the lack of proper space allocation due to the random placement of pallets and engines in the build area.

By studying the situation present in the company, a problem scenario is devised and based on the requirements demanded by that situation objective of the work is finalized. The objectives are formulated as predicting an optimum schedule based on the priority of engines, minimizing the time wastage through value stream mapping, maximizing the output by properly allocating man power and generating a proper space allocation for placing the engines.

2. VALUE STREAM MAPPING

2.1. Product Selected

The project work is done in a company which designs and manufactures diesel engines for various on-road, off-road, marine and generator-set applications. Among the wide variety of products available, a single product which is of highest priority for the customers is chosen for research work. The product for analysis is chosen as the 5.6 L, Diesel engine, since it is of very high importance for the company and a lot of tests are being conducted on this engine.

2.2. Current State Value Stream Map

The product which is of prime importance for the customer is identified and the processes during installation is thoroughly studied. The current state value stream mapping is done by collecting time data required for each operation during the installation.

In VSM, the engine installation process is mainly divided under three heads- planning, build area work and test cells. Each and every activity during installation is carefully observed and plotted down as the current state value stream map. Through, this activity the reasons of time wastage being identified as waiting for engine parts during assembly, delayed decision making by the project manager, delayed movement of the engine due to problems in forklift availability, non-uniform availability of employees during the day shift and night shift and errors during piping fitment

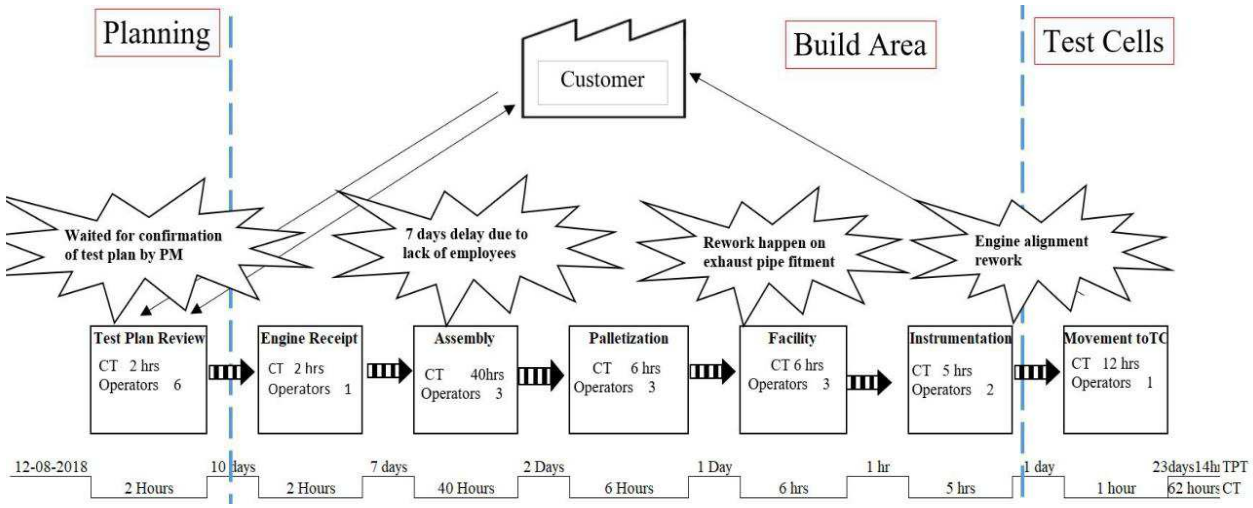

Figure 2: Current State Value Stream Map

3. MODELLING AND SIMULATION

3.1. Arena Model of Current Scenario

To simulate the present workflow a model is developed in the Arena software. In real situation the priority among the arrived engines is decided by the manager based on the 'earliest due date' priority rule. Hence, during modelling the priority is already given to the engines prior to the start of the simulations. Arena model is simulated for a time-period of 4

months to find out in which process a greater number of engine queue is observed and where is waiting time being high.

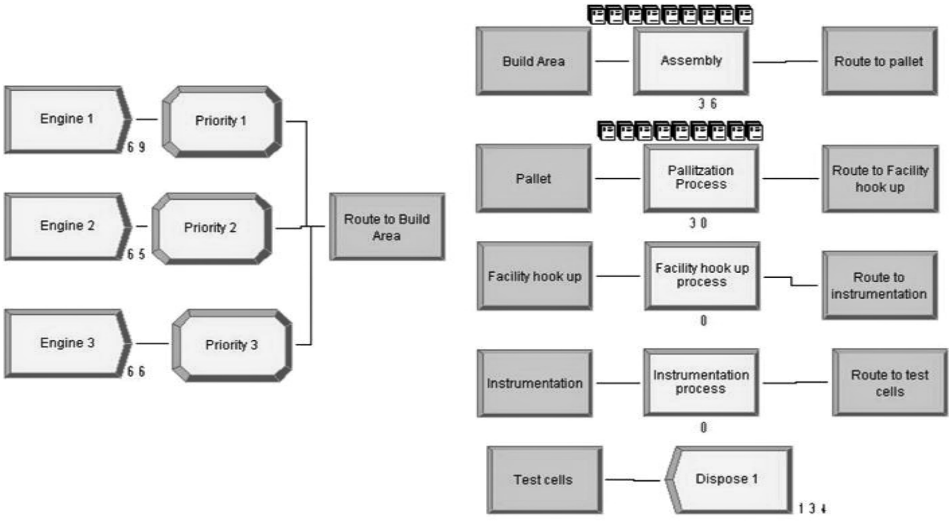

Figure 3: Arena Model of Current Scenario

3.2. Simulation Results of Current Scenario

Through the simulation time required and the number of engines that will undergo the installation process for engine testing during a period of four months is analysed. From the simulation results it is observed that the engine queue is very high during two processes that is assembly and palletization. Hence, more efforts need to be taken to reduce the waiting time incurred in these processes and thereby reduce the engine queue.

From the simulation results assembly queue in observed to be 45.21hours, facility hook up queue is 0.94 hours, the waiting time for instrumentation is 0 hours and palletization process queue is found to be 51.26 hours.

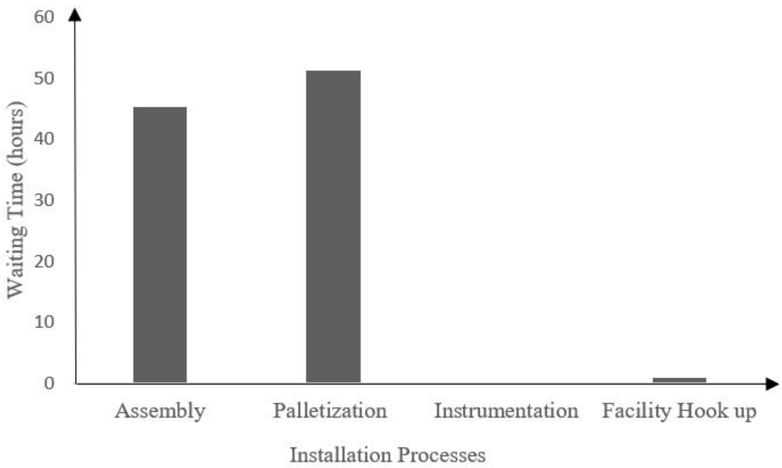

Figure 4: Waiting Time Incurred in Various Processes

4. PROPOSED IMPROVEMENTS

4.1. Proposed Work Flow for Engine Installation

An enhanced work flow is proposed which include two parallel activities. When an engine is having major assembly work it will be taken in for assembly and at the same time another engine which is having minor parts assembly work can be taken in for palletization. Thus, the two operations i.e, assembly and palletization can be done in parallel.

Once the assembly is over that engine can be palletized and taken for further facility hook up. Similarly, sub-assembly works can be done on the palletized engine and then it can be taken for facility hook up. Thus, by performing both processes in parallel the engine queue in these activities can be reduced. This is clearly seen from the simulation results.

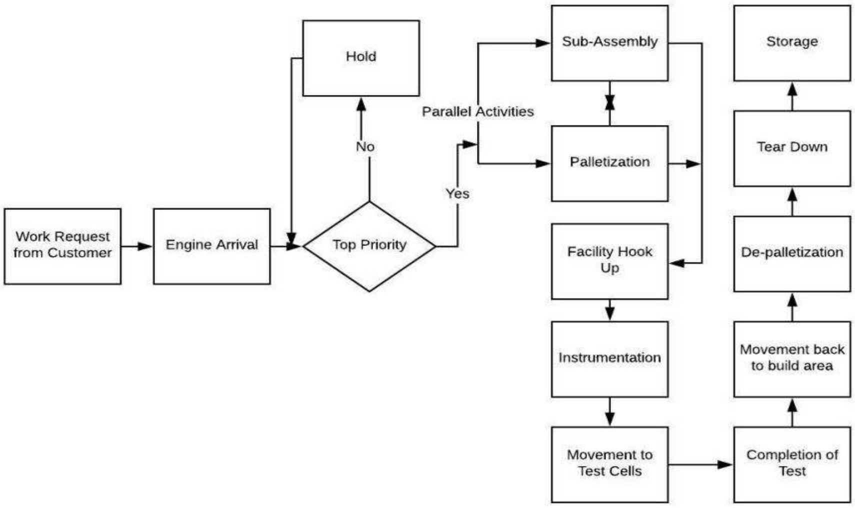

Figure 5: Proposed Work Flow Diagram

4.2. Arena Model for the Proposed Work Flow

In modelling the proposed work flow two sequences are given as the input. First engine will be following sequence 1 and at the same time second engine will be following sequence 2. In this way execution of two parallel processes are obtained. It is observed from the simulation results that 3 workers who are engaged in facility hook up are being under-utilized whereas 3 workers in the assembly process are being over utilized. Hence a redistribution of workers is proposed as 4 workers for doing both assembly and palletization in parallel and 2 workers will be assigned to perform the facility hook up.

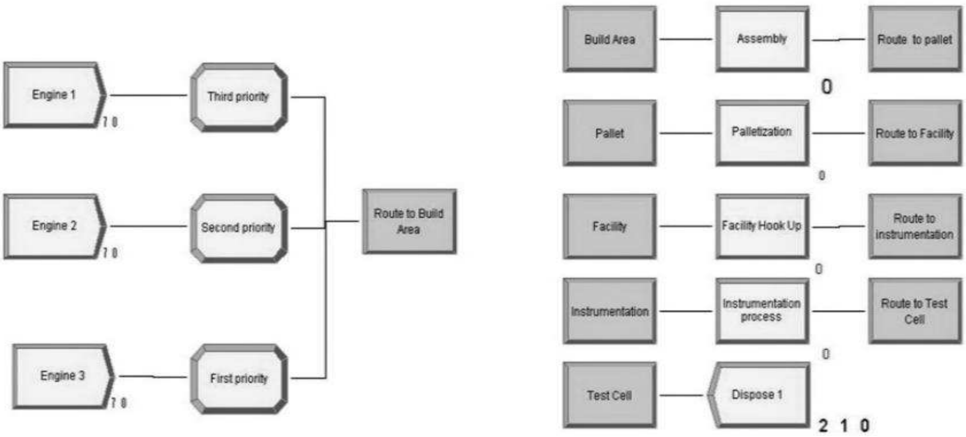

Figure 6: Arena Model for the Proposed Work Flow

4.3. Simulation Results

From the simulation of the proposed scenario the waiting time for each process is observed to be reduced. The queue for palletization is reduced to 2.66 hours whereas the facility hook up queue is 0.14 hours. The waiting time for facility hook up also got reduced to 42.61 hours and there is no queue for instrumentation hook up.

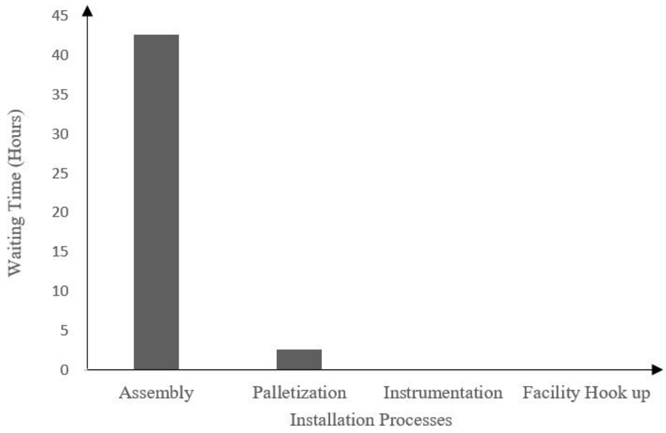

Figure 7: Reduced Waiting Time in Various Processes

Identification of Value Added Activities in the Assembly Process

Even after proposing parallel activities in the workflow engine queue is still present in the assembly process. Hence a detailed study is conducted on various activities involved in the assembly process. And those steps are classified into value-added and non-value-added activities, so that concentration can be given in reducing the time taken for non-value- added activities.

Table 1: Value Added Activities in the Assembly Process

Sl.No.	Value Added Activities in Assembly Process		
	Activities	*Value Added*	*Non-Value Added*
1	Mounting of engine in rig		o
2	Disassembling the parts	●	
3	Waiting for parts		o
4	Assembling the parts	●	
5	Demounting the engine from rig		o

Steps need to be adopted to reduce the time invested in non-value added activities include supplying the required parts along with the engine, so that the time required for waiting for parts can be drastically reduced and for minor assembly, the work can be done on the pallet itself without mounting the engine on the mounting rig.

4.4. Proposed Layout for Build Area

A new layout for built area is proposed which facilitates work on three engines simultaneously since three work stations are present. The work stations are designed in such a way that they have common work tables in between so that tools can be accessed from both sides of the work table. Adaptor plate holder and cupboards are kept in one side so that they do not interfere the smooth movement of engines in work stations.

4.5. Future State Value Stream Map

Based on the proposed improvements the scenario is modelled and simulated in the Arena. The time reduction can be properly understood by plotting the future state Value Stream Map of the proposed scenario.

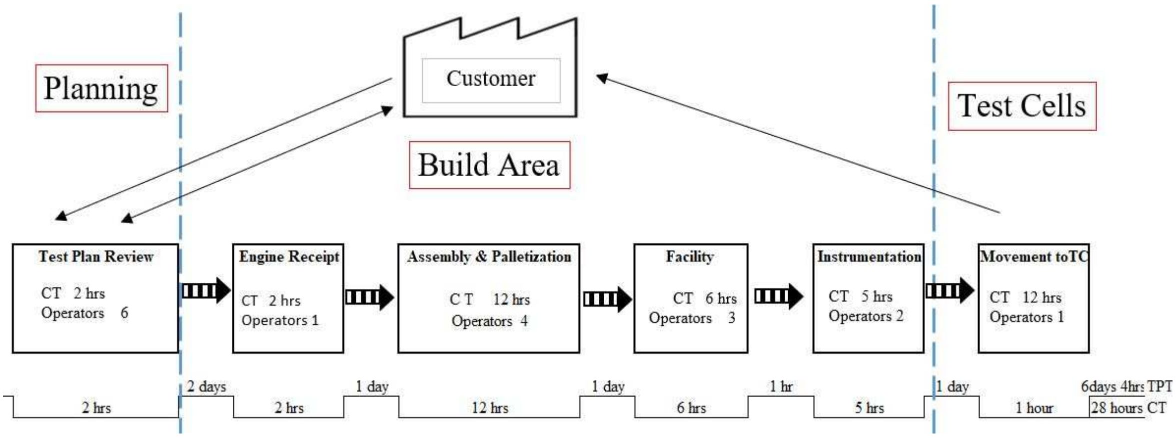

Figure 8: Future State Value Stream Map

5. CONCLUSIONS

In this paper, work is done to explore the applications of lean technologies in improving the workflow of installation activities in engine testing. A product which is of high priority for the customer is chosen for analysis. And a detailed study is conducted on the time and manpower required for the various processes involved in installation work for engine testing. Problems leading to wastage of time and productivity are identified by plotting a value stream map of the current state. The value added and non-value-added activities are identified and the reasons for time wastage are realized. A model of the current scenario is developed in Arena software to get the quantitative data about the time wastage. Based on which an improved work flow is proposed which include two parallel activities. The proposed scenario is also modelled and simulated to show that a drastic reduction in waiting time is observed in two major processes. Further improvements are suggested in reallocating the workers and also a new layout for the build area is suggested. Considering all these improvements a future state value stream map is designed, which shows the effective time reduction obtained through adopting all improvements suggested.

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